Modelling of sediment yield of the highly-erodible meso-scale Isábena basin (Central Spanish Pyrenees)

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Summary
Reservoir sediment caused by uplift erosion often threatens reservoir capacity. This is the case for the 92 km² Barasona Reservoir located at the outlet of the 445-km² Isábena basin (Central Spanish Pyrenees) which experienced considerable losses in storage capacity. The major part of the deposited sediments originates from highly erodible badlands, which are well connected to the river network, facilitating sediment delivery. Water and sediment yield of this basin was modelled using the semi-distributed process-based WASA-SED model. The two major headwater catchments Villarcira and Cabecera with very contrasting erosion response were included in the analysis separately. Despite the challenges of parameter and data availability, the hydrological module of the model performed agreeable after calibration. For the sediment module, numerous uncalibrated variants, based on USLE-derivatives and the transport capacity concept, were compared to monitoring data. The MUSLE and MUST approaches with transport capacity predicted sediment yield best. Pronounced overestimation of sediment yield is apparent for the lower subcatchments, where hydrologic calibration could not be performed adequately. Furthermore, the results suggest that processes in the riverbed (i.e. transportation losses of water, sediment storage in the river channel) have an important control on the sediment yield and thus need further investigation.

1. Study area

Isábena catchment: Pre-Pyrenees, NE-Spain (Fig. 1)
- altitude: 430 - 2200 m a.s.l.
- 750-800 mm a mean rainfall, strong orographic gradient
- diverse lithology and landuse (see Table 1)
- high sediment generation on badland formations
- high sedimentation rates in Barasona reservoir (Fig. 4)

2. Monitoring

Monitoring of discharge and suspended sediment concentration at the outlet of the three sub-catchments:
- recording of water level with capacitive sensor-liner-combination (Fig. 5)
- repeated discharge measurements
- calibration of year 2000
- and official gauge operated by SAH

3. Implementation and Results

3.1 Sediment input to the reservoir (Fig. 9, Table 4)
- erosion equations containing the quasi-2D infiltration: Green-Ampt equation
- evapotranspiration: Shuttleworth & Wallace equation
- subsurface flow: Darcy-type
- overestimation of low and underestimation of high erosion (on catchment and event scale, Tab.5, Fig. 13)

3.2 Sediment yield and modelled sediment yield (Fig. 12, Tab.5)
- erosion equations containing the runoff term (MUSLE, MUST) - good results even for highly erodible badland sub-catchments
- sediment model performance indicated on dry year (2000)

3.3 Outlet concentration and transport capacity (Fig. 11, Tab.5)
- transport capacity limit of lower sub-catchments
- poor representation of sediment storage in the river-channel

3.4 Implementation of transport capacity in the model (Fig. 14)
- calibration of modelled sediment yield-0.5

4. Validation

- error in sediment yield decreases to 48 % with longer simulation period
- period before calibration (dry year)
- underestimation of sediment yield by 39 % (Fig. 9, Tab.4)
- overestimation of sediment yield by 200 % (Fig. 12)
- caused by poor representation of sediment storage in river-channel, acting as a sink during highly erosive periods
- source during periods of low erosion

5. Outlook

Model input data:
- extension of timeliness
- increasing representativeness of rainfall data

Model structure:
- connectivity issues: representation of transmission losses, sediment storage in rivers
- snowmelt processes

Calibration method:
- multi-objective calibration (e.g. separated flow-components; ET from remote sensing)
- genetic algorithms, particle swarm optimisation

Future model application for:
- scenario analysis, climate change
- integrated assessment of reservoir management options

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References
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